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(54) Title: GLASS SHEET HEATING FURNACE

(57) Abstract

A glass sheet heating furnace comprises a heating chamber or enclosure through which individual glass sheets are carried in succession upon a series of aligned rollers. A plurality of heaters, such as gas or electrical resistance heaters or the like, are positioned within the heating chamber and provide radiant heat to the glass sheets. One or more fans are rotatably mounted within the heating chamber to circulate the heated air within the chamber. The fans are preferably mounted in the upper portion of the chamber to provide forced air convection heating of a top surface of the glass sheets. The furnace thereby provides more uniform heating of conveyed glass sheets, maintaining the planar nature of the sheets during heating in a manner which is relatively simple and inexpensive.

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TITLE

GLASS SHEET HEATING FURNACE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to glass sheet heating furnaces of the elongated tunnel-type, wherein glass sheets are heated as they are conveyed therethrough upon a series of aligned rollers in preparation for subsequent treatment steps such as bending, tempering and annealing. More particularly, the invention pertains to such furnaces incorporating improved glass sheet heating means.

2. Description of Related Art

Horizontal elongated tunnel type furnaces are conventionally utilized for the heat treatment of glass, typically in the form of sheets or strips. The furnaces are typically utilized to heat the glass in a controlled manner for further processing at a subsequent work station or stations.

The glass industry, particularly the flat glass industry, has realized considerable success with tunnel-type furnaces and has come to rely substantially on their use for the heat treatment of automotive and architectural glass. Glass sheets employed in the automotive industry, for example, are typically heated to their softening point while transiting a tunnel-type furnace, and then bent by suitable tooling to a prescribed configuration dictated by the design of the automobile in which they are to be installed. After bending, the sheets which are to be employed as side lites and backlites are typically subjected to rapid chilling so as to develop a desired

degree of temper. The sheets which are to be employed as windshields are gradually cooled so as to be annealed, and then laminated to another sheet or sheets in various combinations by means of a plastic interlayer.

Architectural glass is generally supplied in planar form and may be tempered, annealed and laminated much the same as automotive glass. The glass sheets undergo substantially the same processing treatment, except for the bending process, as described above for automotive glass. Of course, if the sheet is to be bent, bending is carried out prior to tempering, annealing and laminating.

Conventional glass sheet heating furnaces generally comprise an elongated refractory chamber through which the sheets are conveyed in succession upon a roller conveyor including a series of spaced rolls, typically having ceramic glass-contacting surfaces. Heat is provided by suitable gas heaters or electrical resistance heaters positioned within the chamber to heat the interior thereof.

Convection between the gas within the furnace chamber and both the top and bottom surfaces of the conveyed glass sheets performs a certain extent of the heating of the glass sheets. Conduction between the heated rolls of the conveyor and the bottom surface of each of the conveyed glass sheets also provides some of the heating. In addition, the heating elements are typically provided both above and below the conveyed glass sheets, so that both the top and bottom surfaces are heated by radiation.

Due to the conduction of heat from the rolls, the bottom surfaces of the glass sheets may be heated more rapidly than the top surfaces. As a result, the glass sheets may bow or warp, the bottom surface of the glass sheet becoming convex. It is important to maintain the glass sheets generally planar during heating on roller

conveyors, as any bowing or warping of the glass sheets is detrimental to many of the subsequent treatment steps such as bending and tempering.

In an attempt to provide uniform heating of glass sheets and maintain the planar nature of the sheets during heating, it has been suggested to provide a glass sheet heating furnace which includes gas jet pump heating. Thus, in U.S. Patent No. 4,505,671, a glass sheet roller conveyor furnace is disclosed which includes upper and lower linear arrays of nozzles connected to a source of compressed gas. The flow of heated gas from the gas jet pumps provides forced convection heating of the top and bottom surfaces of the glass sheets. However, an undue number of the arrays of gas jet pumps are required to provide adequately uniform heating of the conveyed glass sheets, so that the device of U.S. Patent No. 4,505,671 becomes overly complex and expensive.

It would therefore be advantageous to provide a glass sheet heating furnace having a relatively simple but effective means of providing uniform heating of glass sheets to maintain the planar nature of the sheets during heating.

SUMMARY OF THE INVENTION

In accordance with the invention, there is provided a glass sheet heating furnace comprising a heating chamber or enclosure through which individual glass sheets are carried in succession upon a series of aligned rollers. A plurality of heaters, such as gas or electrical resistance heaters or the like, are positioned within the heating chamber and provide radiant heat to the glass sheets. One or more fans are rotatably mounted within the heating chamber to circulate the heated air within the chamber.

The fans are preferably mounted in the upper portion of the chamber to provide forced air convection heating of a top surface of the glass sheets. The furnace thereby provides more uniform heating of conveyed glass sheets, and maintains the planar nature of the sheets during heating, in a manner which is relatively simple and inexpensive.

BRIEF DESCRIPTION OF THE DRAWINGS

The advantages of the invention will become readily apparent to those skilled in the art from the following detailed description of a preferred embodiment when considered in the light of the accompanying drawings, wherein like numerals are employed to designate like parts throughout, and in which:

Fig. 1 is a schematic, longitudinal, elevational view of a glass sheet heating furnace constructed in accordance with the invention; and

Fig. 2 is a transverse sectional view, taken substantially along line 2-2 of Fig 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, and in particular to Fig. 1, there is identified generally at 10 a heating furnace in accordance with the invention for delivering suitable heated glass sheets to an adjacent press bending apparatus 12 or other apparatus (not shown) for bending, tempering or otherwise treating the heated sheets. The heating furnace 10 is formed of a series of sections arranged in end-to-end relationship for forming the tunnel-type enclosure. It is contemplated that each section may be on the order of three to eighteen feet or greater in length. Typically, four such sections, each on the order of eighteen feet in length, may be employed, although as

will be readily apparent the number will be dependent upon a number of factors, such as the length of each section and various operating requirements for the furnace.

As best seen in Fig. 2, each section of the furnace 10 comprises a lower enclosure section 14, an upper enclosure section 15, and a conveyor section 16 for transporting the glass sheets 11 into and through the furnace. At the exit end 17 of the furnace, the sheets 11 are received upon a series of conveyor rolls 18 by which they are carried into the press bending apparatus 12. A lower, female pressing ring 19 may lift the sheets from the conveyor rolls and press them against an upper male pressing surface 20 in the conventional manner, and then deposit the bent and shaped sheets upon the conveyor rolls for advancement out of the press bending station 12.

The lower enclosure section 14 comprises a structural framework including cross members 22 and vertical side braces 23. The cross members 22 are typically supported upon longitudinal beams carried by pedestals resting upon a supporting surface, such as a building floor, none of which is shown in the drawings. Tubular longitudinal bracing members 27 are provided along the tops of the side braces 23. A suitable insulating layer 28 is provided, and a refractory lining 29 covers the insulating layer and defines the interior surface of the enclosure. The upper surface 30 of the bottom wall of the refractory lining may be provided with longitudinally extending recesses 31 in which elongated electric resistance strip heating elements 33 are mounted for providing heat within the enclosure beneath the conveyor.

The upper enclosure sections 15 comprise an outer casement 35 serving as a framework for the section. Angle-shaped support members 42 having inwardly directed

horizontal legs 43 are affixed along the lower extremities of the casement 35. A layer 44 of insulating material is disposed along and above a refractory cap or arch 45. The arch-shaped layer 44 and cap 45 are supported at their lower edges upon a plate 46 secured to the horizontal leg 43 of the member 42. A wall (not shown) at each end of the furnace encloses the upper enclosure section 15 above the conveyor. A suitable gap is provided between the wall and the conveyor for permitting passage of the sheets 11 into and out of the furnace on the conveyor.

The refractory cap 45 includes an exposed surface 48 facing the interior of the furnace and, in particular, the glass sheets 11 as they move through the furnace on the conveyor 16. There may be formed in the surface 48 a plurality of spaced, longitudinally extending recesses 49 for receiving and retaining elongated electric resistance strip heating elements 51. The heating elements 51 are connected to a source of electrical energy (not shown) in the conventional manner for providing heat to the furnace chamber.

While the configuration of the furnace roof or arch is not critical in accordance with the invention, a furnace roof or arch as illustrated in Fig. 2, having an elliptical configuration in cross-section, is advantageous in relatively uniformly distributing heat from the heating elements while simultaneously enabling application of heat differentially across the furnace. The elliptical roof configuration, which is described in greater detail in U.S. Patent No. 4,983,202, which is incorporated by reference herein, provides relatively uniform heating in the central region, and allows differential heating of the glass along

the side regions of the furnace. Of course, the furnace roof or arch may be flat or have other desired configurations.

The conveyor 16 may be of any suitable type, but preferably comprises a plurality of spaced, individual rollers 79. The rollers 79 are longitudinally aligned and positioned between the lower and upper enclosure sections 14 and 15 so as to carry individual glass sheets 11 from a loading station 80 at the entrance to the furnace 10, into and through the furnace for transfer to the rolls 18, by which they are carried into the press bending apparatus 12. Such rollers for present day furnaces generally have a ceramic work contacting surface and may be fabricated as of fused silica or quartz. A conventional drive system (not shown) for the rollers 79 is also provided.

Provision is made for enclosing the side area of the furnace around the rollers 79 and between the upper and lower enclosure sections to isolate the furnace interior from the ambient external atmosphere. In order to do so while permitting the rollers to be readily removed and replaced, as best seen in Fig. 2, a lower roll packing member 85 may be disposed atop each side wall of the lower enclosure section to enclose, in conjunction with cooperating upper roll packing members 86, the area between and around the individual rollers.

In accordance with the invention, the furnace 10 of the invention is provided with one or more fans 90 positioned within the upper enclosure section 15 thereof. The fan 90 is comprised of a plurality of circumferentially spaced apart paddles or blades 91 mounted proximate the lower end of a rotatable shaft 92 for rotation therewith. The blades 91 are mounted at angle in such a manner that, upon rotation thereof, the air within the furnace chamber

is circulated, with the air directly beneath the fan 90 being forced downward or, if the direction of rotation is reversed, the air beneath the fan 90 being drawn upward. The lower end of the shaft 92 passes through a ceramic insulating sleeve 93 mounted in the refractory cap 45 and extends into the interior of the furnace 10. The shaft 92 is preferably closely fit with, but does not contact, the sleeve 93. The blades 91 and shaft 92 of the fan 90 may be formed of stainless steel or other suitable material.

A fan mounting frame 94 is secured to the outer casement 35 of the upper furnace section 15. The upper end of the shaft 92 is rotatably journalled in bearings (not shown) secured to the frame 94. A drive unit 95 is also mounted to the frame 94. The drive unit 95 includes a motor 96, preferably a variable speed AC motor, having an output shaft 97. The output shaft 97 of the motor 96 is coupled by means of a drive chain or belt 98 to the upper end portion of the shaft 92 in the conventional manner. An intermediate portion of the shaft 92 may be housed within an enclosure 99 secured within the upper section 15 of the furnace.

In one embodiment of the invention, the fans 90 are caused to rotate so as to draw the air upward and circulate it about the furnace chamber. The circulation of the air results in a more uniform air temperature within the furnace chamber and serves to remove some of the excess heat from the rolls 79. In an alternate, preferred embodiment of the invention, the fans 90 are caused to rotate so as to force the relatively hotter air at the roof of the furnace interior down into contact with the top surface of the conveyed glass sheets 11. As a result, the heating of the top surfaces of the glass sheets 11 is increased to off-set, at least in part, the increased

heating of the sheets due to conduction from the rolls 79. The circulation of the air also results in a more uniform air temperature within the furnace chamber and serves to remove some of the excess heat from the rolls 79.

Since radiant heat from the heating elements typically becomes the dominant source of heating of the sheets 11 in the downstream sections of the furnace 10, the one or more fans 90 are preferably positioned within the furnace 10 near the upstream end thereof; that is, proximate the loading station 80. In the preferred embodiment illustrated in Fig. 1, a single fan 90 is provided in each the first three sections of the furnace 10.

The furnace in accordance with the invention, including one or more forced air convection fans, provides more uniform heating of glass sheets, maintaining the planar nature of the sheets during heating. Further, the furnace of the invention achieves this result in a manner which is relatively simple and inexpensive.

WHAT IS CLAIMED IS:

1. A furnace for heating glass sheets, comprising an elongated, generally horizontally extending heating chamber, a conveyor for carrying glass sheets into and through said heating chamber, a plurality of heaters positioned within said heating chamber, and a one or more fans rotatably mounted within said heating chamber.

2. A furnace as defined in claim 1, wherein said conveyor includes a plurality of rollers disposed in spaced aligned relation throughout the length of said heating chamber.

3. A furnace as defined in claim 1, wherein said one or more fans are positioned above said glass sheets.

4. A furnace as defined in claim 3, wherein said one or more fans each includes one or more blades secured to a rotatable shaft, said blades being oriented so as to provide forced air convection heating to a top surface of said glass sheets when said shaft is rotated.

5. A furnace as defined in claim 1, wherein said one or more fans includes one or more blades secured to a rotatable shaft, said furnace further including a variable speed motor for selectively imparting rotation to said shaft.

6. A furnace as defined in claim 1, wherein said heating chamber includes a roof having an elliptical configuration in cross-section.

7. A furnace as defined in claim 1, wherein said elongated heating chamber includes an upstream end at which said glass sheets enter said chamber and a downstream end at which said glass sheets exit said chamber, and wherein said one or more fans are positioned proximate the upstream end of said heating chamber.

8. A furnace as defined in claim 1, wherein said plurality of heaters are gas heaters.

9. A furnace as defined in claim 1, wherein said plurality of heaters are electrical resistance heaters.

10. A furnace for heating glass sheets, comprising an upper furnace enclosure section and a lower furnace enclosure section together defining an elongated, generally horizontally extending heating chamber, conveyor means including a plurality of rollers disposed in spaced aligned relation throughout the length of said heating chamber for carrying glass sheets into and through said heating chamber, a plurality of heaters positioned within said heating chamber, and a one or more fans rotatably mounted within the upper furnace enclosure of said heating chamber.

11. A method of heating glass sheets as said sheets are conveyed through an elongated enclosed heating chamber, comprising supplying radiant heat to said sheets, and operating one or more fans within said heating chamber to provide circulation of the air within said chamber and more uniformly heat said glass sheets.

12. A method as defined in claim 11, wherein radiant heat is supplied to said sheets while simultaneously operating said one or more fans to provide circulation of the air within said chamber.

13. A method as defined in claim 11, wherein said one or more fans are operated to provide forced air convection heating to a top surface of said glass sheets.

14. A method as defined in claim 11, wherein said elongated heating chamber includes an upstream end at which said glass sheets enter said chamber and a downstream end at which said glass sheets exit said chamber, and wherein said one or more fans provide greater circulation of air in the upstream end of said heating chamber relative to that provided in the downstream end of said heating chamber.

15. A method as defined in claim 11, wherein said glass sheets are conveyed through said heating chamber upon aligned roller members.

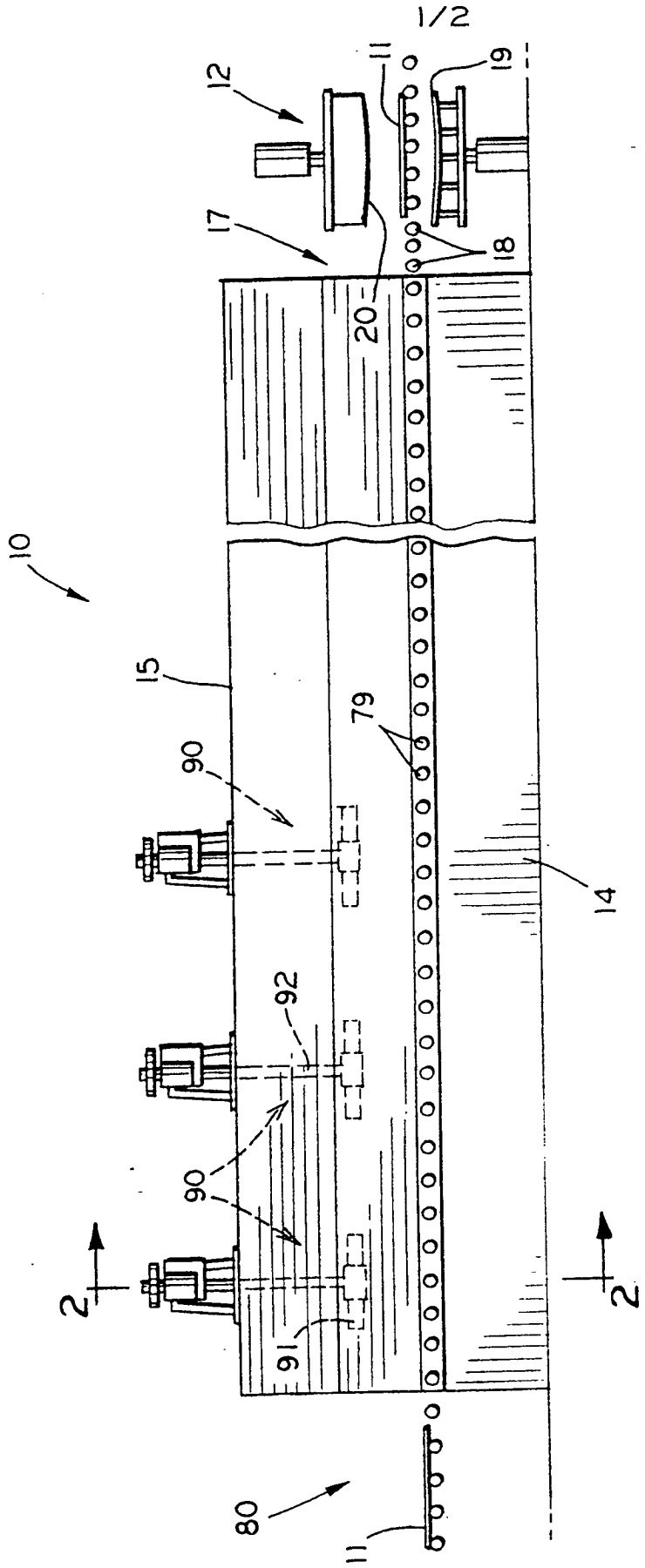
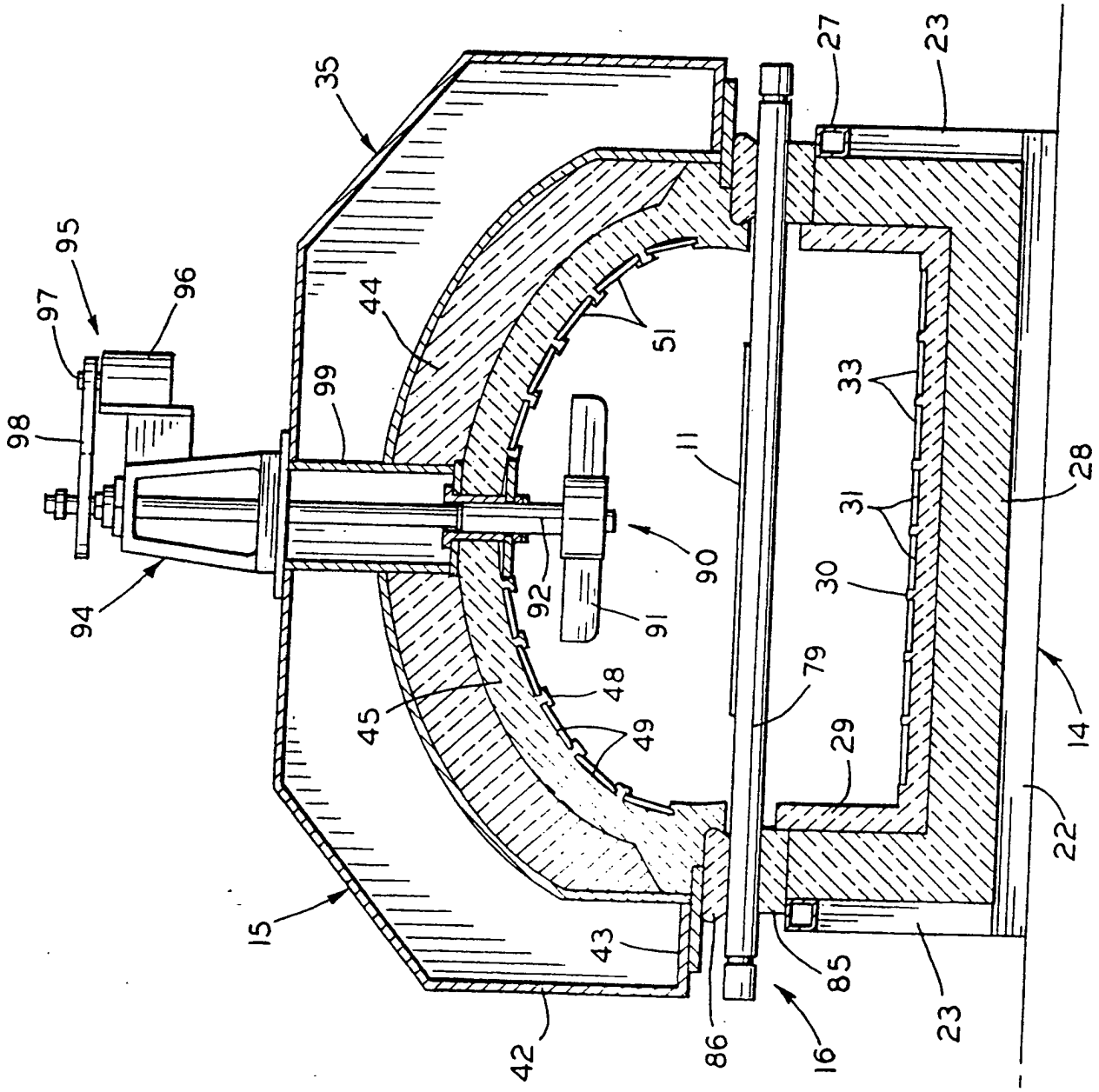


FIG. 1

FIG. 2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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/11535

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : CO3B 23/02, 25/08, 27/044, 35/16
US CL : 65/102, 106, 119

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 65/102, 106, 119, 182.2, 268, 273

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

STN/CAS WPIDS
searched for US equivalent of WO98/03439

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X ---- P,Y	WO 98/03439 A (GLASSROBOTS OY) 29 January 1998 (29-01-98), page 4 and figures.	1-7, 10-13 15 ---- 8, 9, 14
Y	US 4,620,864 A (MCMASTER) 04 November 1986 (04-11-86), column 11 and figure 4.	8, 9
Y	US 4,390,359 A (REUNAMAKI) 28 June 1983 (28-06-83), column 5, lines 22-40.	14
A	Database WPIDS, week 9641, Alexandria, VA: Derwent Information Ltd., AN 96-404377, Class L01, FI 97378 B (GLASSROBOTS OY), abstract.	1-15

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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